AGU 2003 Fall Meeting

Implications of Cl leaching on chlorine-36 studies at Yucca Mountain, Nevada

Guoping Lu, Eric L. Sonnenthal, and Gudmundur S. Bodvarsson

GPLu@lbl.gov; elsonnenthal@lbl.gov; gsbodvarsson@lbl.gov

Earth Sciences Division

Lawrence Berkeley National Laboratory

Berkeley, CA 94720, USA

Abstract. Chlorine-36 was generated from nuclear tests in the 1950s and 1960s and has been used to identify fast flow paths at Yucca Mountain, the proposed repository for high-level nuclear waste. Bomb-pulse ^{36}Cl, brought into the subsurface by infiltrating rainwater, presumably resides along fracture surfaces because of the extremely low rock matrix permeability. However, leaching a rock sample to extract this salt inevitably extracts pore-water chloride (Cl) and rock matrix chloride, thereby making it difficult to obtain reproducible measurements or detect the bomb-pulse nuclide. Complexities introduced by these sources of older chloride include dilution of bomb-pulse ^{36}Cl/Cl ratios for samples from strata with a high Cl concentration, variations in measured ratios as a function of leaching time, rock-chip size, and differing effects of active leaching from those of passive leaching. This work provides both a conceptual model and a mathematical solution to the leaching processes, and examines the role of sample leaching in the ^{36}Cl studies of Yucca Mountain rocks. An analytical solution is derived for the diffusion of Cl and ^{36}Cl in composite media (rock matrix and water) to accommodate variable diffusivity. This solution is subsequently used to develop a leaching model that takes into account bomb-pulse signal, matrix pore water, and relatively hard-to-leach components (isolated fluid inclusion and mineral boundary salts). The model is then applied to samples from stratigraphic units at Yucca Mountain to obtain leachate concentrations in different setup methods (protocols), including duration, chip size, and gravitational settling of the water-rock mixture. The model results show that the probability of detecting a $^{36}Cl/Cl$ bomb-pulse signal is severely diminished under longer leaching times and smaller rock-fragment sizes. Leaching times of 1 to 10 hours are most likely to be successful in detecting a bomb-pulse signal. Bomb-pulse $^{36}Cl/Cl$ ratios are more likely to be observed if pore-water Cl concentrations were initially low prior to the introduction of bomb-pulse carrying waters.